No Difference in Clinical Outcomes, Revision Rates, and Sports Participation Between HT & QT Autografts for ACLR in Paediatric and Adolescent Patients

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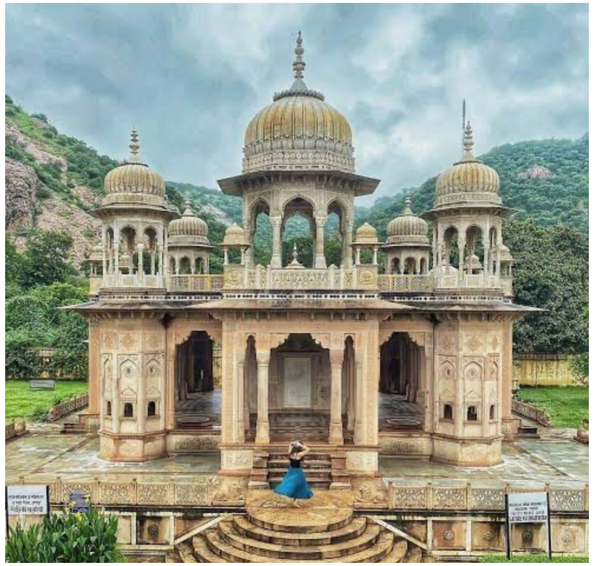

A Retrospective Cohort Study

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Disclosures

- Nothing to disclose

Background

- In recent years, anterior cruciate ligament (ACL) injuries in children and adolescents (age 18 years) have been increasing.

- The factors responsible for this rise are increased participation in high-level competitive sports, year-round training, and sports specialization.

- Historically, ACL injuries in this population have been managed nonoperatively with bracing, physical therapy, and activity modification.

- However, poor outcomes in the form of increased instability, irreparable meniscal tears, chondral injuries, and inability to return to previous activity levels have been reported after nonoperative treatment.

- Therefore, ACLR is the treatment of choice for pediatric and adolescent ACL injuries.

> Am J Sports Med. 2011 Dec;39(12):2582-7. doi: 10.1177/0363546511420818. Epub 2011 Sep 14.

Degeneration of the knee joint in skeletally immature patients with a diagnosis of an anterior cruciate ligament tear: is there harm in delay of treatment?

J Todd R Lawrence [1], Nina Argawal, Theodore J Ganley

Review > Am J Sports Med. 2014 Nov;42(11):2769-76. doi: 10.1177/0363546513510889. Epub 2013 Dec 4.

Anterior cruciate ligament tears in children and adolescents: a meta-analysis of nonoperative versus operative treatment

David E Ramski [1], Wajdi W Kanj [2], Corinna C Franklin [3], Keith D Baldwin [4], Theodore J Ganley [5]

- Although, over 90% of adolescent athletes return to sports after ACLR
- A significantly higher incidence of graft failure is reported in adolescents and children compared with adults.

Meta-Analysis > Knee Surg Sports Traumatol Arthrosc. 2018 Apr;26(4):1019-1036. doi: 10.1007/s00167-018-4830-9. Epub 2018 Jan 13.

Over 90 % of children and adolescents return to sport after anterior cruciate ligament reconstruction: a systematic review and meta-analysis

Jeffrey Kay [1], Muzammil Memon [1], Robert G Marx [2], Devin Peterson [1], Nicole Simunovic [3], Olufemi R Ayeni [4 5]

> J Bone Joint Surg Am. 2017 Jun 7;99(11):897-904. doi: 10.2106/JBJS.16.00758.

Return to Sport After Pediatric Anterior Cruciate Ligament Reconstruction and Its Effect on Subsequent Anterior Cruciate Ligament Injury

Travis J Dekker [1], Jonathan A Godin, Kevin M Dale, William E Garrett, Dean C Taylor, Jonathan C Riboh

- Many factors are responsible for higher failure rates such as lower compliance with rehabilitation protocols, higher activity levels, and higher anxiety levels.

- Graft choice also affects functional outcomes and graft failure.

› Am J Sports Med. 2015 Jan;43(1):121-7. doi: 10.1177/0363546514552788. Epub 2014 Oct 16.

Patient predictors of early revision surgery after anterior cruciate ligament reconstruction: a cohort study of 16,930 patients with 2-year follow-up

Daniel Andernord [1], Neel Desai [2], Haukur Björnsson [2], Mattias Ylander [3], Jón Karlsson [2], Kristian Samuelsson [2]

› Orthop J Sports Med. 2019 Sep 17;7(9):2325967119872450. doi: 10.1177/2325967119872450. eCollection 2019 Sep.

Transphyseal Anterior Cruciate Ligament Reconstruction in the Skeletally Immature: Quadriceps Tendon Autograft Versus Hamstring Tendon Autograft

Andrew T Pennock [1 2], Kristina P Johnson [1], Robby D Turk [1], Tracey P Bastrom [1], Henry G Chambers [1 2], Kelly E Boutelle [1], Eric W Edmonds [1 2]

› Knee Surg Sports Traumatol Arthrosc. 2018 Apr;26(4):989-1010. doi: 10.1007/s00167-018-4865-y. Epub 2018 Feb 17.

2018 International Olympic Committee consensus statement on prevention, diagnosis and management of paediatric anterior cruciate ligament (ACL) injuries

Clare L Ardern [1 2], Guri Ekås [3 4 5], Hege Grindem [6], Håvard Moksnes [4], Allen Anderson, Franck Chotel [7], Moises Cohen [8], Magnus Forssblad [9], Theodore J Ganley [10], Julian A Feller [11 12], Jón Karlsson [13], Mininder S Kocher [14 15], Robert F LaPrade [16 17], Mike McNamee [18], Bert Mandelbaum [19], Lyle Micheli [14 15 20], Nicholas Mohtadi [21], Bruce Reider [22], Justin Roe [23], Romain Seil [24 25], Rainer Siebold [26 27], Holly J Silvers-Granelli [28], Torbjørn Soligard [29 30], Erik Witvrouw [31], Lars Engebretsen [3 4 5 29]

- Use of allografts in pediatric ACLR has poor clinical outcomes.
- Traditionally, the hamstring tendon (HT) is most commonly used graft.
- However, recently, the Stability trial and other studies cast doubt on using HT autograft (in isolation) in at-risk athletes (ligamentous laxity, younger age, increased tibial slope, high-grade pivot shift, and early return to sports).

› Am J Sports Med. 2015 Jul;43(7):1583-90. doi: 10.1177/0363546515578836. Epub 2015 Apr 21.

Risk Factors and Predictors of Subsequent ACL Injury in Either Knee After ACL Reconstruction: Prospective Analysis of 2488 Primary ACL Reconstructions From the MOON Cohort

Christopher C Kaeding [1], Angela D Pedroza [2], Emily K Reinke [3], Laura J Huston [3]; MOON Consortium; Kurt P Spindler [4]

› Am J Sports Med. 2015 Nov;43(11):2696-705. doi: 10.1177/0363546515589168. Epub 2015 Jun 11.

Revision Risk After Allograft Anterior Cruciate Ligament Reconstruction: Association With Graft Processing Techniques, Patient Characteristics, and Graft Type

Samir G Tejwani [1], Jason Chen [2], Tadashi T Funahashi [3], Rebecca Love [2], Gregory B Maletis [4]

Meta-Analysis › J ISAKOS. 2022 Apr;7(2):87-93. doi: 10.1016/j.jisako.2021.10.001. Epub 2021 Nov 17.

Quadriceps tendon has a lower re-rupture rate than hamstring tendon autograft for anterior cruciate ligament reconstruction - A meta-analysis

Eoghan T Hurley [1], Edward S Mojica [2], Ajay C Kanakamedala [2], Robert J Meislin [2], Eric J Strauss [2], Kirk A Campbell [2], Michael J Alaia [2]

Randomized Controlled Trial › Am J Sports Med. 2022 Feb;50(2):384-395. doi: 10.1177/03635465211061150. Epub 2022 Jan 20.

Predictors of Graft Failure in Young Active Patients Undergoing Hamstring Autograft Anterior Cruciate Ligament Reconstruction With or Without a Lateral Extra-articular Tenodesis: The Stability Experience

- Moreover, the HT autograft may compromise medial stability of the knee, and produce weakness in knee flexion and internal rotation. Also, it may cause sensory deficits due to the injury to the saphenous nerve.

› Am J Sports Med. 2017 Mar;45(4):819-825. doi: 10.1177/0363546516677728. Epub 2016 Dec 28.

Should the Ipsilateral Hamstrings Be Used for Anterior Cruciate Ligament Reconstruction in the Case of Medial Collateral Ligament Insufficiency? Biomechanical Investigation Regarding Dynamic Stabilization of the Medial Compartment by the Hamstring Muscles

Mirco Herbort [1], Philipp Michel [1], Michael J Raschke [1], Nils Vogel [1], Martin Schulze [1], Alexander Zoll [1], Christian Fink [2], Wolf Petersen [3], Christoph Domnick [1]

Review › Orthop Traumatol Surg Res. 2017 Dec;103(8S):S245-S248. doi: 10.1016/j.otsr.2017.09.002. Epub 2017 Sep 6.

Complications following harvesting of patellar tendon or hamstring tendon grafts for anterior cruciate ligament reconstruction: Systematic review of literature

A Hardy [1], L Casabianca [2], K Andrieu [3], L Baverel [4], T Noailles [3];
Junior French Arthroscopy Society

- On the other hand, the quadriceps tendon (QT) autograft is gaining popularity for ACL reconstruction:-
  - A greater mean cross-sectional area
  - Greater load to failure,
  - And lower donor-site morbidity

› Knee Surg Sports Traumatol Arthrosc. 2023 Jun;31(6):2461-2468.
doi: 10.1007/s00167-022-07200-2. Epub 2022 Oct 20.

Revision ACL reconstruction using quadriceps, hamstring and patellar tendon autografts leads to similar functional outcomes but hamstring graft has a higher tendency of graft failure

Amit Meena [1 2], Luca Farinelli [3], Christian Hoser [1 2], Elisabeth Abermann [1 2], Akshya Raj [4], Caroline Hepperger [1], Mirco Herbort [2 5], Christian Fink [6 7]

Meta-Analysis › Knee Surg Sports Traumatol Arthrosc. 2023 Aug;31(8):3316-3329.
doi: 10.1007/s00167-023-07380-5. Epub 2023 Mar 24.

No difference in patient reported outcomes, laxity, and failure rate after revision ACL reconstruction with quadriceps tendon compared to hamstring tendon graft: a systematic review and meta-analysis

Amit Meena [1 2 3], Stefano Di Paolo [4], Alberto Grassi [5], Akshya Raj [6], Luca Farinelli [7], Christian Hoser [1 2], Sachin Tapasvi [8], Stefano Zaffagnini [5], Christian Fink [9 10]

Comparative Study › Arthroscopy. 2016 Jan;32(1):71-5. doi: 10.1016/j.arthro.2015.06.051.
Epub 2015 Sep 14.

Biomechanical Comparison of Quadriceps and Patellar Tendon Grafts in Anterior Cruciate Ligament Reconstruction

Raj H Shani [1], Erica Umpierez [2], Michael Nasert [3], Elise A Hiza [4], John Xerogeanes [5]

Randomized Controlled Trial › Br J Sports Med. 2020 Feb;54(3):183-187.
doi: 10.1136/bjsports-2019-101000. Epub 2019 Nov 8.

Quadriceps tendon grafts does not cause patients to have inferior subjective outcome after anterior cruciate ligament (ACL) reconstruction than do hamstring grafts: a 2-year prospective randomised controlled trial

Martin Lind [1], Torsten Grønbech Nielsen [2], Ole Gade Soerensen [2], Bjarne Mygind-Klavsen [2], Peter Faunø [2]

> Orthop J Sports Med. 2024 Feb 1;12(2):23259671231224501. doi: 10.1177/23259671231224501. eCollection 2024 Feb.

Primary Versus Revision ACL Reconstruction Using Quadriceps Autograft: A Matched-Control Cohort Study

Amit Meena [1 2], Luca Farinelli [3], Christian Hoser [1 2], Elisabeth Abermann [1 2], Caroline Hepperger [1], Mohit Kumar Patralekh [4], Mirco Herbort [2 5], Christian Fink [1 2]

Review > Knee Surg Sports Traumatol Arthrosc. 2023 Jun;31(6):2274-2288. doi: 10.1007/s00167-022-07281-z. Epub 2022 Dec 19.

Quadriceps tendon autograft with or without bone block have comparable clinical outcomes, complications and revision rate for ACL reconstruction: a systematic review

Amit Meena [1 2], Riccardo D'Ambrosi [3 4], Armin Runer [5], Akshya Raj [6], Manish Attri [6], Elisabeth Abermann [1 2], Christian Hoser [1 2], Christian Fink [7 8]

Review > J ISAKOS. 2024 Aug;9(4):672-681. doi: 10.1016/j.jisako.2024.03.007. Epub 2024 Mar 16.

The "Golden Age" of quadriceps tendon grafts for the anterior cruciate ligament: a bibliometric analysis

Riccardo D'Ambrosi [1], Srinivas Bs Kambhampati [2], Amit Meena [3], Danko Dan Milinkovic [4], Elisabeth Abermann [5], Christian Fink [6]

> Arthroscopy. 2024 Aug 27:S0749-8063(24)00611-X. doi: 10.1016/j.arthro.2024.08.013. Online ahead of print.

No Clinical Advantage of Harvesting a Patellar Bone Block Compared to All Soft Tissue Graft in Primary Quadriceps Tendon Anterior Cruciate Ligament Reconstruction

Armin Runer [1], Amit Meena [2], Lena Jucho [3], Guido Wierer [4], Robert Csapo [5], Elisabeth Abermann [2], Mirco Herbort [6], Christian Hoser [2], Christian Fink [7]

- Therefore, the QT autograft for ACLR in paediatric and adolescent athletes seems to be a logical choice.

- However, there is no consensus regarding the graft choice for ACL reconstruction in these young patients.

- The **purpose** of the study was to compare:

➢ Patient-reported outcome measure (PROM),

➢ Knee stability

➢ Graft failure rates

➢ Sports participation after ACLR

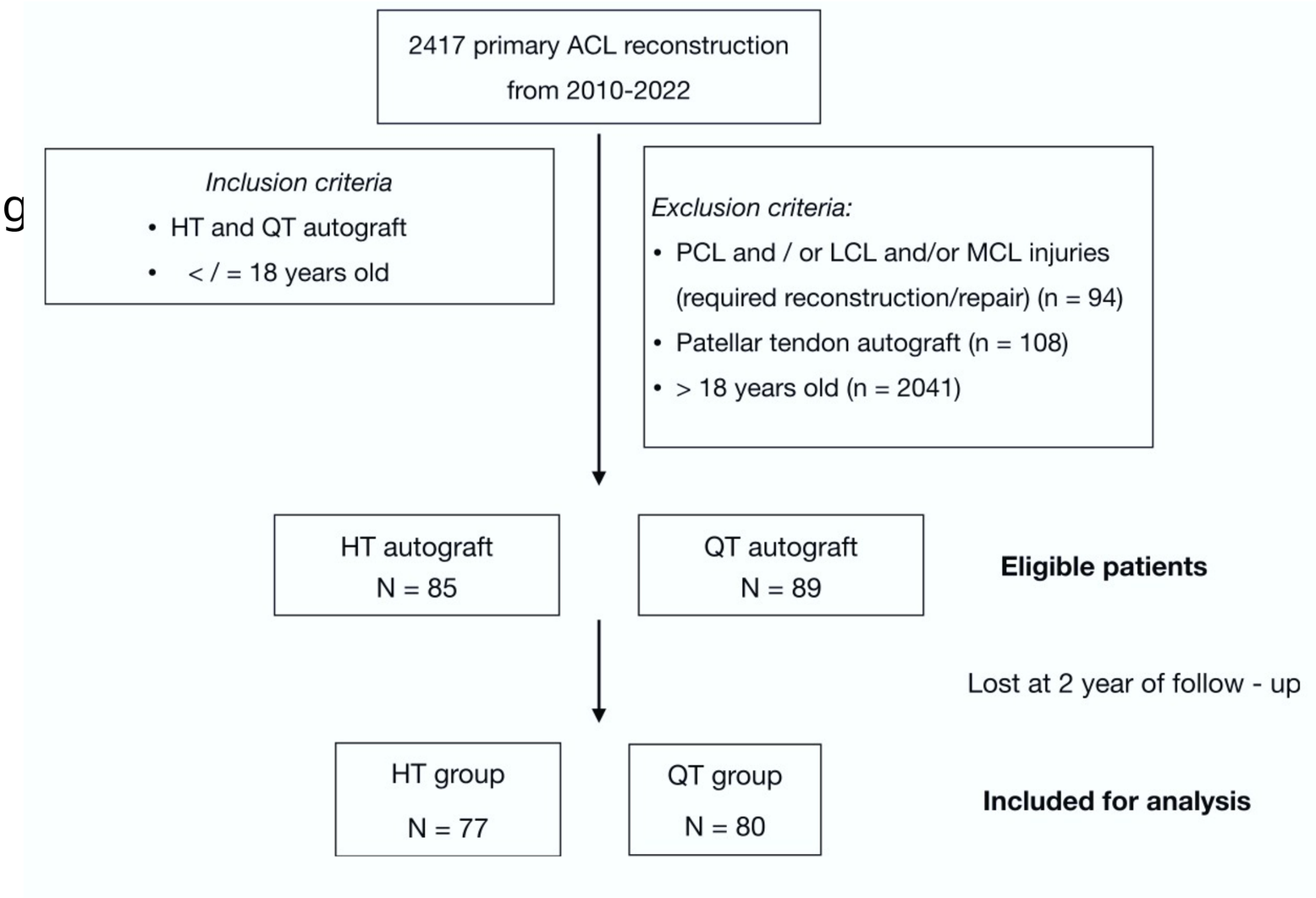
Between HT and QT grafts for ACLR in patients aged ≤18 years

- We hypothesized that the QT autograft would result in better functional outcomes with a high rate of return to sporting activity and a low rate of graft failure after ACLR compared with the HT autograft in this population.

Methods

Inclusion Criteria:

- Primary ACL reconstruction using either HT or QT autograft,
- Age ≤18 years,
- Minimum 2-year follow-up.



- The majority of the patients were operated on within1 week of ACL injury. Therefore, pre-injury PROMs were recorded and used as a baseline

At follow-up, patients were assessed for:

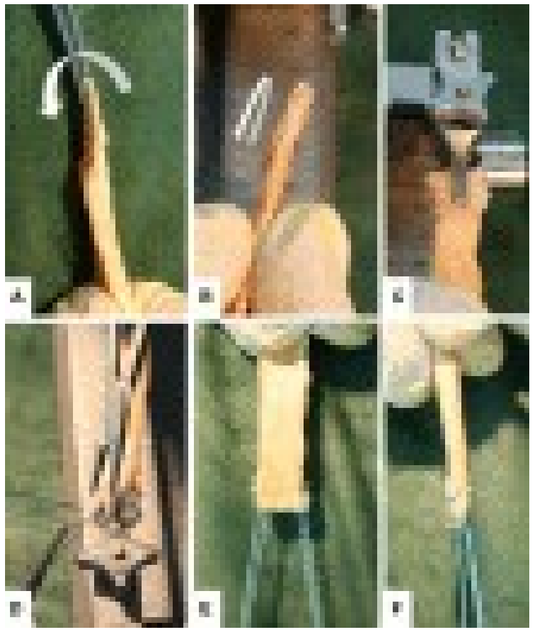
1. PROMs (Lysholm knee score, Tegner activity level, and VAS for pain)
2. Knee stability (Anterior drawer test, Lachman test, Pivot-shift test)
3. Graft failure rates
4. Sports participation

Surgical Technique

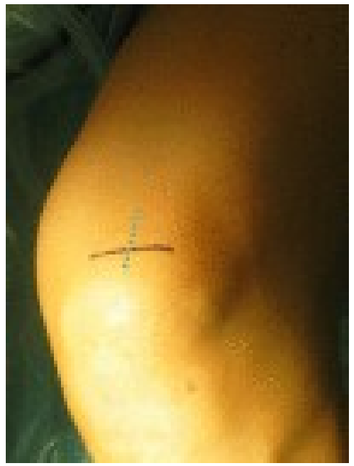
- Transphyseal or all-epiphyseal technique used according to age and Tanner stage.
- A bioabsorbable interference screw or button was used at tibial side
- A suspensory fixation used at femoral side.

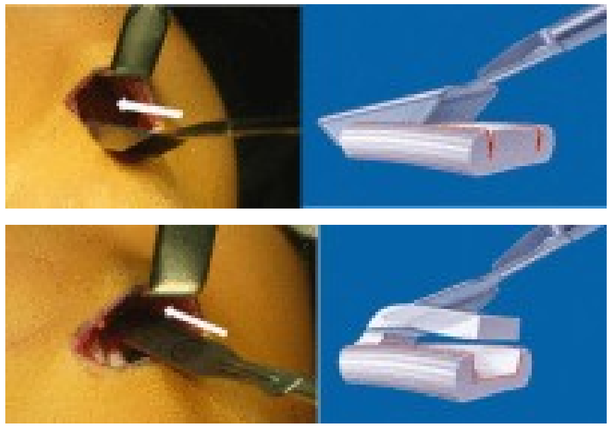
- HT autograft → quadrupled semi-T alone was used primarily, but if the thickness of the graft was ≤ 6.5 mm then it was augmented with the gracilis tendon

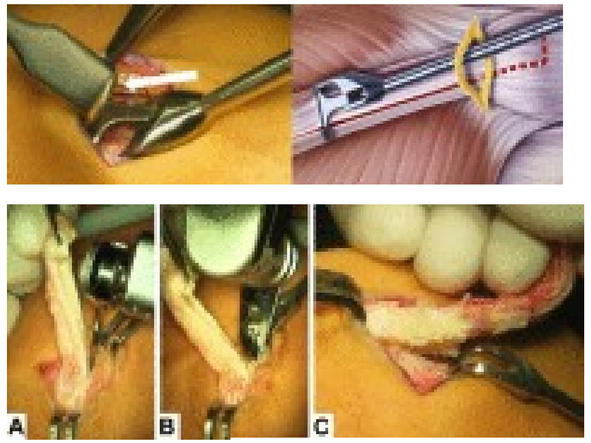
Surgical Technique

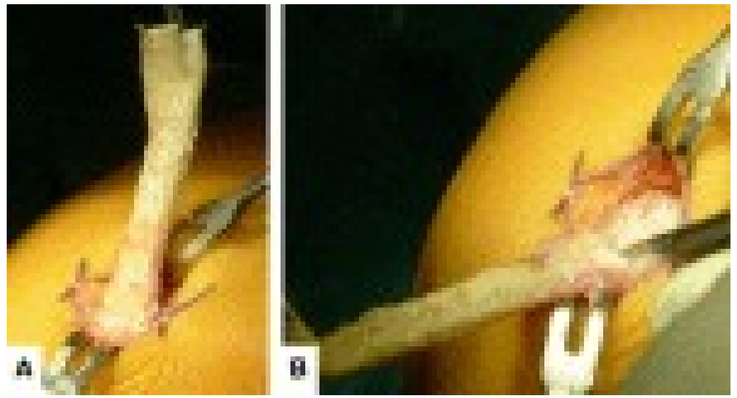


- A minimally invasive technique was used for QT autograft harvesting
- All soft tissue quad tendon was used
- The selection of the graft (QT vs HT) was not randomized but was chosen according to the patient's preference after receiving a detailed discussion









› Arthrosc Tech. 2014 Aug 11;3(4):e509-13. doi: 10.1016/j.eats.2014.06.003. eCollection 2014 Aug.

Minimally invasive harvest of a quadriceps tendon graft with or without a bone block

Christian Fink [1], Mirco Herbort [2], Elisabeth Abermann [3], Christian Hoser [1]

Surgical Technique

- Lateral extra-articular tenodesis (LET), specifically the modified Ellison technique, was performed in both groups based on preoperative and surgical factors such as

- Return to high-risk sports,
- Grade 2 or more pivot shift,
- Generalized ligamentous laxity,
- Genu recurvatum10°,
- Contralateral ACL injuries, and
- Meniscal repair.

Rehabilitation

- The rehabilitation protocol was identical in both groups.

- Patients followed physiotherapy and rehabilitation programs for 9 to 12 months.

Results

- The 2 groups did not differ significantly in terms of baseline demographics and concomitant injuries (P > .05).

TABLE 1
Patient Characteristics and Associated Injuries[a]

	QT (n = 80)	HT (n = 77)	*P* Value
Age, y			.28[b]
Mean ± SD (range)	15.4 ± 2.5 (7.0-18.0)	14.9 ± 2.6 (7.0-18.0)	
Median (IQR)	16.1 (13.8-17.4)	15.2 (13.6-16.9)	
Sex			.87[c]
Male	28 (35)	49 (64)	
Female	52 (65)	28 (36)	
Isolated ACL reconstruction	43 (54)	51 (66)	.14[c]
Concomitant injuries	37 (46)	26 (34)	
Meniscal injuries[d]	34 (43)	22 (29)	.10[c]
Medial	16 (20)	11 (14)	.40[c]
Lateral	18 (23)	15 (20)	.70[c]
Treatment			>.99[c]
Meniscal repair	32 (40)	23 (30)	
Meniscectomy	5 (6)	3 (4)	
Cartilage lesions	1 (1)	2 (3)	.62[c]
Medial collateral ligament injuries (treated with repair)	2 (3)	2 (3)	>.99[c]

[a]Data are expressed as n (%) unless otherwise specified. ACL, anterior cruciate ligament; HT, hamstring tendon; IQR, interquartile range; QT, quadriceps tendon.
[b]Mann-Whitney test.
[c]Fisher exact test.
[d]4 patients had both medial and lateral meniscus injuries.

Results

- No significant difference between groups for all epiphyseal ACLR or LET (P > .05)

TABLE 2
Surgical Characteristics[a]

	HT (n = 77)	QT (n = 80)	*P* Value[b]
All-epiphyseal ACL reconstruction	28 (36)	26 (33)	.619
Lateral extra-articular tenodesis	8 (10)	10 (13)	.804

[a]Data are expressed as n (%). ACL, anterior cruciate ligament; HT, hamstring tendon; QT, quadriceps tendon.
[b]Fisher exact test.

- No significant difference was found in the baseline PROMs (Lysholm, Tegner activity level and VAS for pain) between the two groups (p>0.05).
- Similarly, no significant difference was observed at 2 years of follow-up between the two groups for PROMs (p>0.05).
- Lysholm knee score, Tegner activity level and VAS for pain score improved to pre-injury level in both the groups and no significant difference was found between baseline and 2-year follow-up for Lysholm, Tegner and VAS scores (p>0.05).

TABLE 3
Patient-Reported Outcome Measure Scores[a]

	Baseline		2 y		
	HT (n = 77)	QT (n = 80)	HT (n = 77)	QT (n = 80)	*P* Value[b]
Lysholm					
Mean ± SD (range)	93.2 ± 17.8 (0-100)	92.8 ± 15.4 (18-100)	92.5 ± 14.3 (0-100)	88.9 ± 19.9 (0-100)	.06
Median (IQR)	100 (95-100)	100 (95-100)	99 (89-100)	95 (86-100)	.06
P value[c]	.788		.101		
Tegner					
Mean ± SD (range)	7.0 ± 1.9 (1-10)	7.0 ± 1.6 (2-10)	6.9 ± 2.1 (1-10)	6.7 ± 1.8 (0-10)	.923
Median (IQR)	7 (6-8)	7 (6-8)	7 (6-8)	7 (6-8)	.346
P value[c]	.588		.336		
VAS					
Mean ± SD (range)	0.7 ± 1.7 (0-8)	1.2 ± 2.1 (0-8)	0.6 ± 1.1 (0-5)	0.7 ± 1.2 (0-6)	.624
Median (IQR)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)	.451
P value[c]	.069		.463		

[a]HT, hamstring tendon; IQR, interquartile range; QT, quadriceps tendon; VAS, visual analog scale.
[b]Kruskal-Wallis test.
[c]Mann-Whitney test.

Results

- Both the groups achieved pre-injury level sports participation (p>0.05).

TABLE 4
Sports Participation[a]

	Baseline		2 y		
	HT (n = 77)	QT (n = 80)	HT (n = 77)	QT (n = 80)	*P* Value
None	1 (1)	2 (3)	2 (3)	2 (3)	.593[b]
Occasionally	3 (4)	5 (6)	5 (7)	7 (9)	.220
2-3 times/wk	26 (34)	25 (31)	31 (40)	36 (45)	
>5 times/wk	47 (61)	48 (60)	39 (51)	35 (44)	
P value	.904[b]		.856[b]		

[a]Data are expressed as n (%). HT, hamstring tendon; QT, quadriceps tendon.
[b]Fisher exact test.

Results

- Graft failure occurred in 11 (14%) and 8 (10%) patients of the HT and QT groups, respectively.
- The rate of failure did not differ significantly between groups ($p>0.05$).
- No significant differences were observed in knee stability with Lachman test and pivot-shift test at baseline and follow-up

TABLE 5
Clinical Examination Findings[a]

	Baseline		2 y	
	HT (n = 77)	QT (n = 80)	HT (n = 77)	QT (n = 80)
Lachman test				
Negative	0 (0)	0 (0)	75 (97)	78 (98)
Positive	77 (100)	80 (100)	2 (3)	2 (3)
P value	>.99		>.99	
Pivot-shift test				
Grade 0	0 (0)	0 (0)	75 (97)	78 (98)
Grade 1 +	8 (10)	6 (8)	2 (3)	2 (3)
Grade 2 +	23 (30)	28 (35)	0 (0)	0 (0)
Grade 3 +	46 (60)	46 (58)	0 (0)	0 (0)
P value	.692		>.99	

[a]Data are expressed as n (%). HT, hamstring tendon; QT, quadriceps tendon.

Strength

1. This was the first study comparing HT and QT autografts for ACL reconstruction in patients aged 18 years or younger

Limitation

2. Study focused on subjective outcomes.
3. Small sample size led to underpowered statistical analysis for graft failure.
4. The addition of LET was limited in both groups.
5. The follow-up period was short
6. The selection of the graft was not randomized

Clinical relevance

- ACL injuries are increasing in children and adolescents and there is no consensus regarding the graft choice.
- QT autograft is gaining popularity for ACLR.
- Surgeons should be aware of all the available graft options, including HT and QT autografts
- The findings of this study will help in decision-making in graft selection for ACLR in young athletes.

Conclusion

- A QT autograft for ACL reconstruction led to similar clinical outcomes, revision rates, and sports participation compared with an HT autograft in pediatric and adolescent patients.

- However, the choice of graft remains to be clarified.

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Thank You!

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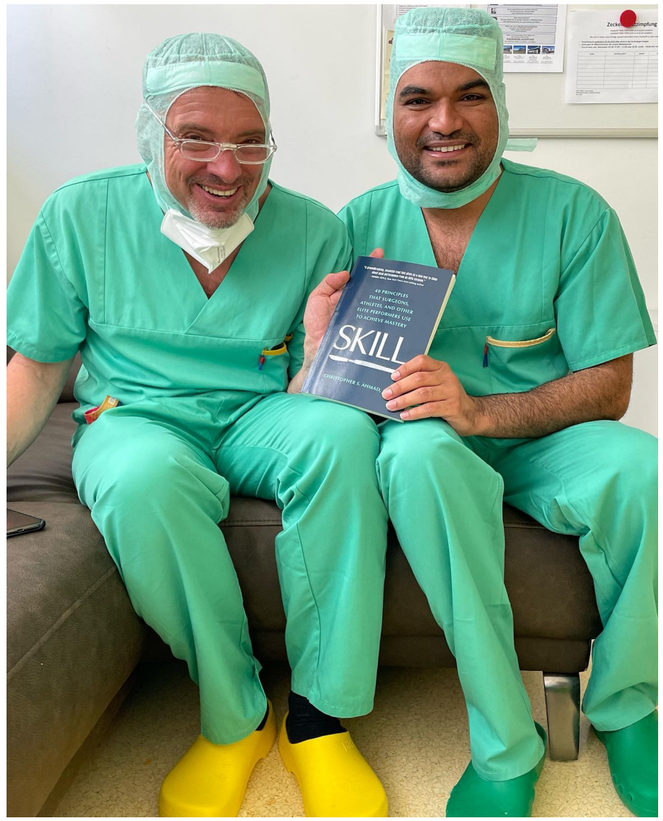

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Amit Meena, MS, DNB, Luca Farinelli, MD, Darren de SA, MD, MBA, Riccardo D'Ambrosi, MD, Christian Hoser, MD, Elisabeth Abermann, MD, Mirco Herbort, MD, and Christian Fink, MD +5 View all authors and affiliations

Volume 53, Issue 12 | https://doi.org/10.1177/03635465251370616 | View article versions

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